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CONTAGION OF FINANCIAL CRISES: A LITERATURE REVIEW OF THEORETICAL AND EMPIRICAL FRAMEWORKS

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Abstract

The timing and virulence of the current global financial crisis do not seem to be adequately explained by the fundamental problems facing many of the economies that have been seriously affected, particularly those in East Asia, raising important questions about the nature of spillovers and contagion. This note attempts to organise the wide range of definitions, causes and measurements of contagion in the vast literature on this area under a conceptual framework. It reviews the causes of contagion and examines the possible channels through which shocks might be transmitted. It also provides an overview of the empirical tests used in the literature for the presence and characteristics of contagion in financial markets.

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I. INTRODUCTION

Events unfolding in the past year remind us that we are living in a highly globalised world and that events that occur in one part of the world can have tremendous impact on a market oceans away. The timing and virulence of the current crisis do not seem to be adequately explained by the fundamental problems facing many of the countries and markets concerned, particularly those in east Asia. This raises important questions about the nature of spillovers and contagion. The linkage through which the transmission of shocks takes place may be pinned down at times, while at other times there seems to be an absence of apparent links.

By drawing from the vast literature on the subject, we seek to review in this note the channels of contagion in a conceptual framework and give an overview of empirical methodologies for testing the incidence of contagion. This complements Cheung, Fung, and Tam (2008), in which we looked at cross-country equity return correlations as an indicator for assessing possible contagion risk in the region. This note is structured as follows. The next section discusses the economic meaning and causes of contagion. Section III examines the possible channels through which shocks might be transmitted. Section IV gives an overview of the various empirical methodologies in the existing literature related to the testing of the incidence of contagion. Finally, the last section concludes.

II. WHAT IS CONTAGION AND WHY DOES IT ARISE?

Contagion refers to the transmission of a crisis from one economy to others, and has been an important feature in past financial crisis episodes. It is striking to see from the experience of previous episodes of financial crises, how an initial country-specific shock was rapidly transmitted to markets of very different sizes and structures around the globe. The timing and virulence of financial crises often seem quite unrelated to the fundamental problems facing the countries and markets concerned. It is not uncommon to find crises triggering severe attacks on other currencies, despite the weak linkages of trade and capital flow linkages among the economies concerned. This has prompted a surge of interest in solving the contagion puzzle. Given the economic and financial instability contagion entails, it is useful to develop an understanding of how shocks can be transmitted between countries, so that steps can be taken to reduce financial contagion, especially in emerging markets which are more fragile, and particularly need stability in order to develop and grow. The following are some commonly-cited hypotheses that explain contagion.

1. Asymmetric information and expectation formation (herding)

Contagion is commonly referred to being the result of herding behaviour. When fundamentals and common shocks do not fully explain the relationship among countries, spillover effects are attributed to herding behavior, either rational or irrational. Such phenomenon is explained by models of expectations formation in the context of imperfect and asymmetric information. These models explain why herding behaviour

among investors and fads can be rational. If each individual investor has some private information (and knows that others has it too), then observing the actions of others gives some clues as to what they know (assuming that they cannot credibly share their information), making it rational to imitate them.

Different mechanisms help explain herding behaviour, with some studies emphasising asymmetric information. Information is costly to obtain, so less informed investors may choose to follow the "leader", causing markets to move together. Or, investors may not be able to differentiate one foreign market from another, and when they see a crisis in a foreign economy they reassess the risks of investing abroad, so that a crisis in one economy may lead to wholesale withdrawal of investments in all foreign markets.

2. Macroeconomic feedback models

In macroeconomic feedback models, adverse expectations of a particular event (typically a devaluation) make that event more likely (typically, by raising borrowing costs or wages). For example, the decision to devalue is triggered when foreign exchange reserves falls below a certain threshold. A higher domestic interest rate, triggered by fears of devaluation or default, feeds back in an adverse way on the economy's prospects, by making a devaluation or default more likely because it increases the economy's foreign debt servicing or because higher interest rates trigger a run on the banking system, a contraction of domestic liquidity, and an outflow of reserves. In this case, shifts in expectations are to some extent self-fulfilling, and there are several rational expectations equilibria.

3. Models of liquidity and bank runs

In models of liquidity and bank runs, a large number of bank customers withdraw their deposits because they believe the bank is, or might become, insolvent. Lenders/depositors need to form expectations of what other depositors are doing: if others run, then it is optimal for an individual to run too, if the amount of liquid assets available to the bank is less than demand deposits outstanding. As a bank run progresses, it generates its own momentum, in a kind of self-fulfilling prophecy: as more people withdraw their deposits, the likelihood of default increases which encourages further withdrawals. The destabilising effect, if serious enough, can lead to bankruptcy of the bank.

In Diamond and Dybvig (1983), it is a realisation of a shock that determines whether each individual wants to consume now rather than later. However, even those who have planned to defer consumption may want to withdraw their money if they think a bank run will occur, and if they do, the bank run will exhaust the bank's liquid assets. The outbreak of the crisis will depend on whether or not the depositors coordinate in the run or no-run equilibrium.

4. Wake-up call

The wake-up call hypothesis refers to the case where a crisis elsewhere provides new information about the seriousness of problems in the home economy. This could sometimes be explained by similarities in the fundamentals and economic structure between economies. As such, economies with weak macroeconomic fundamentals would be more prone to contagion in crisis conditions. For example, if a country with a weak banking system is discovered to be susceptible to a currency crisis, investors could reevaluate the strength of the banking system in other economies and adjust their expected probabilities of a crisis accordingly. However, it is also possible that the change in beliefs is overdone, perhaps for reasons related to fads. It may involve shifts in sentiment, some of which are not related to knowledge of the true fundamentals of the economy.

III. POSSIBLE CHANNELS OF THE TRANSMISSION OF SHOCKS

Investors' behaviour under market imperfections and the presence of multiple equilibria as discussed in the previous section can cause a shock to be transmitted from one economy to another. However, whether a shock is transmitted, and whether it has a large impact on another country will depend very much on how vulnerable the real sector and financial system are. An economy is more vulnerable if it has weak macroeconomic fundamentals or financial system. The degree of vulnerability also increases with the number and size of linkages with the real economy and financial system of other economies. Thus, the transmission channels can be real (economic) or financial. The rest of this section discusses each of these channels through which shocks, whether real or intermediary-specific, might be transmitted from one economy or one type of economic unit to another.[1]

1. Real linkages

One of the most commonly studied real channels of contagion involves *trade linkages*. If the export market of an economy experiences a shock such that its demand for imports declines, the exporting economy's trade account will be adversely affected. The deterioration in the trade account will undermine economic growth, and if the deterioration is large relative to the availability of external financing, investors may reassess the investment risks involved. In another scenario, an economy loses competitiveness when the currency of a major trading partner depreciates substantially. The authorities may attempt to safeguard the economy's competitiveness by devaluing its currency. If investors foresee this decision as likely, they would cut their demand for the country's assets, bringing about a decline in the currency, a fall in asset prices, and perhaps capital outflows, which may trigger a crisis in the end. Glick and Rose (1998) show that trade linkages help explain cross-country correlations in exchange market pressure during crisis episodes, after controlling for other macroeconomic factors. Others have found that sharing a common trade bloc will make an economy particularly susceptible to contagion from a member economy (Kaminsky and Reinhart 1998). Indeed a game of

[1] *Real shocks* refer to shocks to the real sector of the economy, while an i*ntermediary-specific shock is a* shock that hits a bank or a non-bank financial institution, and is specific in its origin to that bank or financial institution.

competitive devaluations can cause greater currency depreciations than that required by the initial deterioration in fundamentals (Corsetti et al 1998). There might be elements of competitive devaluations in the propagation of the Asian financial crisis of 1997-98.

2. Financial linkages

While trade linkages may help explain contagion between economies that are closely related, they leave some cases of contagion unanswered, such as the one between Russia and Brazil in late 1990s, as the two countries did not have substantial trade links. Sometimes financial linkages might be the more important channels. A financial crisis in one economy can lead to reductions in trade credit, foreign direct investments and other capital outflows. There are many ways that financial linkages help propagate spillovers or contagion, and the extent is partly determined by the degree of financial market integration between the economies concerned.

i. Common creditor

A shock could begin with an international bank which then spills over to the real sectors of other economies through decreased lending by the bank. This has happened in the current crisis with many banks in industrial countries pulling back from lending to emerging market economies after sustaining losses in their securities investment. A common creditor might pull lending in an economy when a real shock in another economy has weakened its capital position (Kaminsky and Reinhart, 2000).

ii. Interconnected lenders

The financial linkages through which contagion can be transmitted can be more complicated in the presence of a chain of interconnected lenders. Under this domino model of financial contagion, for example, if an international bank, say Bank A, has borrowed from Bank B in another country, and Bank B has borrowed from Bank C, then the default of A impacts B, which then impacts C. Similarly, a shock in Country A can cause Bank A to incur loss in its lending business in this country. If Bank A has deposits with another bank, say Bank B, that has loans in Country B, then the problems with Bank A can cause it to withdraw its deposits from Bank B, causing problems to Bank B as well. Bank B may in turn alter its loan portfolio in Country B. Both examples result in the shock being transmitted from Country A to Country B through a chain of interconnected lenders.

iii. Interactions under market-based financial system

The above linkages view financial contagion traditionally through the lens of defaults. However, in a modern market-based financial system, contagion can be transmitted through price changes and the measured risks and marked-to-market capital of financial institutions. When balance sheets are marked to market, asset-price changes will be reflected immediately on balance sheets and will trigger response from financial market participants. Even if exposures are dispersed widely throughout the financial system, the potential impact of a shock can be amplified many-fold through market price changes.

iv. Portfolio rebalancing

Financial market contagion can occur due to portfolio rebalancing (Kaminsky and Reinhart, 1998). There are different motivations for financial institutions to rebalance across markets. One motivation arises due to *correlated liquidity shocks*. For example, investment funds that foresee future redemptions after a shock in one economy may need to raise cash by selling assets in other economies.

The need for liquidation also occurs when a negative shock in one economy diminishes the value of *leveraged investors*' collateral, leading them to sell part of their holdings in unaffected economies to meet margin calls. For example, *hedge funds* may be highly leveraged, so that losses in one market lead to a write down of capital that requires shrinking the portfolio size, for a given leverage ratio, and this leads to liquidation of their holdings in a number of markets. Furthermore, according to Shin and Adrian (2008), there is evidence pointing to procyclical leverage where financial intermediaries actively adjust their balance sheets i.e. having high leverage during booms and low leverage during busts. This makes financial intermediaries' net worth even more sensitive to price changes and shifts in measured risks.

Another motivation for portfolio rebalancing is *cross-market hedging*. Contagion occurs through the cross-market hedging channel because investors respond to shocks by readjusting their hedges to macroeconomic risks. In addition, if an investor experiences a *wealth shock*, it may provoke a reexamination of the riskiness of his portfolio holdings and bring about a voluntary decline in the leverage ratio. For example, investors with decreasing relative risk aversion may optimally choose to move their portfolios toward less risky assets as their wealth declines.

IV. EMPIRICAL METHODOLOGY FOR TESTING CONTAGION

The number of empirical research studying *contagion* has grown extensively in the past few decades. There is a range of various quantitative methodologies in the related literature which can be categorised by the different definitions of contagion. According to the World Bank, they can be conceptually divided into three categories, depending on how specific the contagion definition is. We set out below the definitions and describe the empirical methodology for testing contagion.

Broad definition:

This is the broadest definition where contagion refers to the cross-country transmission of shocks or general cross-country spillover effects. Under this definition, contagion can be transmitted through real or financial linkages, so that it is sometimes called fundamentals-based contagion (Calvo and Reinhart, 1996). These forms of co-movements may reflect normal interdependence, and do not need to be related to crises, despite they are emphasised during periods of crises.

Restrictive definition:

The second definition of contagion refers to the transmission of shocks to other economy

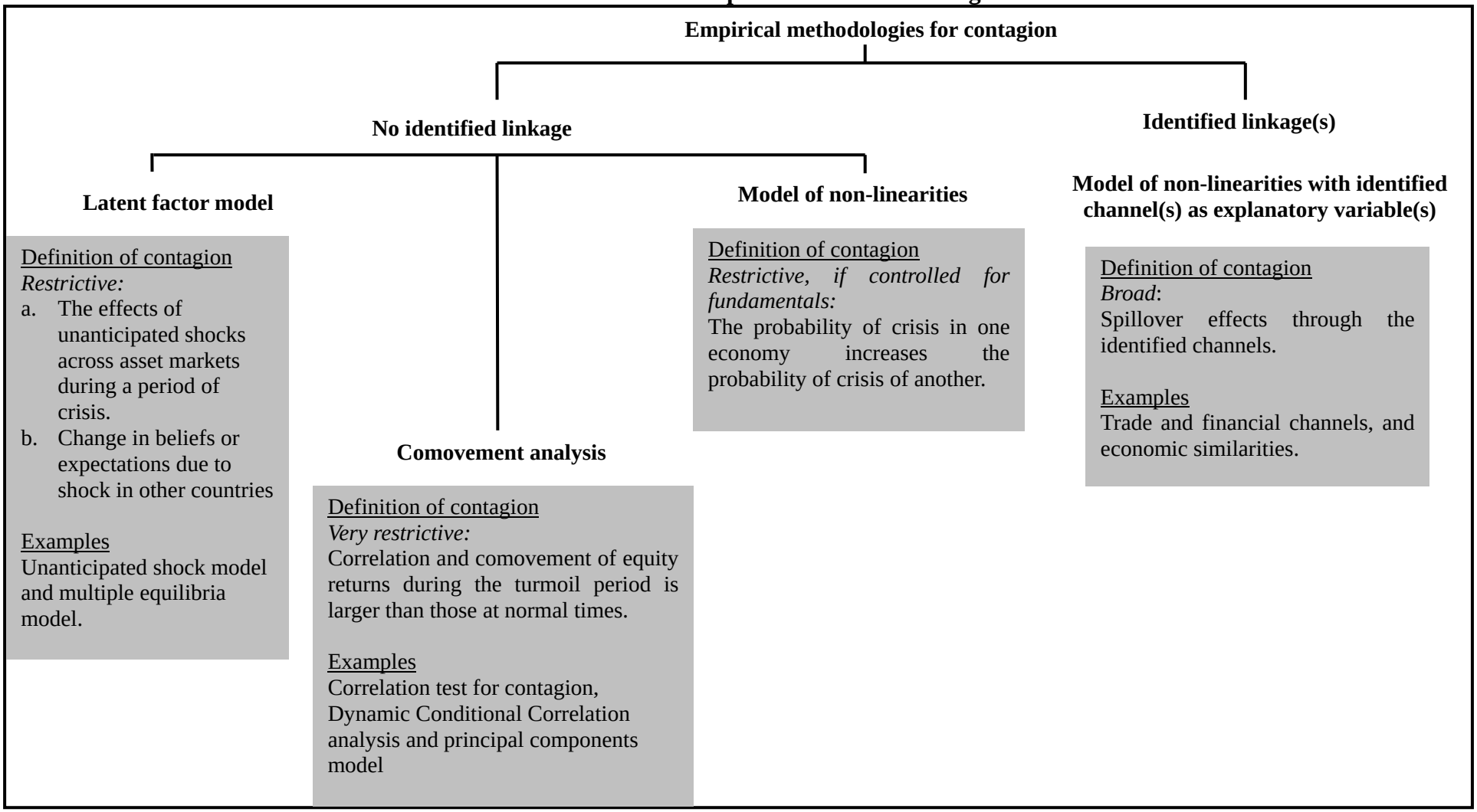
or cross-country correlation, beyond any fundamental link among the economies and beyond common shocks. It is sometimes known as excess co-movement.

Very restrictive definition:

In the third definition, contagion occurs when cross-country correlations increase during "crisis times" as compared with correlations during "tranquil times". This is a very restrictive definition and is used mostly in empirical analyses to establish the contagion incidence and measurements. Such studies usually consider transmissions across geographical borders for a particular asset market, such as the stock market.

Dungey et al. (2004) provide a very comprehensive survey of the recent empirical studies of this subject. On the one hand, the most common approach adopted in the studies of contagion involves models with no identified channel of transmission, where most of these approaches stem from the framework of the latent-factor model (Sharpe, 1964) by examining a particular parameter related to the transmission of an unanticipated shock on the asset return from one economy to other(s). On the other hand, there are some other studies concerning the spillover effects (on asset returns) across economies through some identified channels. All of these methodologies are related to the long ambiguous term *contagion* whose grounds are not quite unified. The objective of this section is to provide a brief introduction of the concepts and principles of the common approaches used in the studies of contagion. Chart 1 gives a brief summary on the various methods used in the study of contagion.

Chart 1. An overview of empirical studies on contagion



1. Models with no identified channel of transmission

There are three major types of models in the literature namely, (i) latent factor model, (ii) comovement analysis, and (iii) models of asymmetries and nonlinearities. The concepts and principles of each of these models are briefly discussed below.[2]

i. *Latent factor model*

The term contagion is commonly defined in this type of model as the effect of shocks across asset markets during a period of crisis. This shock could exist as an unanticipated shock in a simple asset return model, or as a trigger of the change in beliefs or expectations of investors in a regime switching model. Since the exogenous shock is not observable, various types of latent factor models are employed to investigate the existence of contagion.

a. Unanticipated-shock model

This type of analysis is based on the following bivariate factor model:

$$\begin{aligned} y_{1,normal,t} &= \lambda_1 w_t + \delta_1 u_{1,t} \\ y_{2,normal,t} &= \lambda_2 w_t + \delta_2 u_{2,t} \end{aligned} \tag{1}$$

$$\begin{aligned} y_{1,crisis,t} &= \lambda_1 w_t + \delta_1 u_{1,t} \\ y_{2,crisis,t} &= \lambda_2 w_t + \delta_2 u_{2,t} + \gamma_{2,1} u_{1,t} \end{aligned} \tag{2}$$

where $y_{i,normal,t}$ and $y_{i,crisis,t}$ are demeaned asset returns in economy *i* during the pre-identified normal and crisis periods respectively; w_t represents common shocks that impact upon all asset returns in the system (of both economies) with loading λ_i; the terms $u_{i,t}$ are idiosyncratic latent factor of the asset market in economy *i* at time *t* with loading δ_i. The expressions in (1) and (2) imply that the asset return in economy 2 is also being affected by the idiosyncratic shocks of other economies with loading $\gamma_{2,1}$ during the crisis period, reflecting that there is contagion from economy 1 to economy 2 if $\gamma_{2,1}$ is significant. Under a set of standard assumptions on the properties of w_t and $u_{i,t}$[3], the test of contagion can be done by focusing on the changes in the volatility of pairs of asset returns between the normal and the crisis periods. From equations (1) and (2), the respective covariances between the asset returns of economies 1 and 2 in each of the two states are:

$$Normal: \quad E(y_{1,normal,t} y_{2,normal,t}) = \lambda_1 \lambda_2 \tag{3}$$

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[2] To simplify the discussion, the bi-variate version of each model is discussed here as a conceptual introduction. Dungey et al. (2004) provide a comprehensive discussion of the general multi-variate versions of these models.

[3] The assumptions are: (1) both w_t and $u_{i,t}$ are standardised stochastic processes with zero mean and unit variance; (2) w_t and $u_{i,t}$ are independent and (3) $u_{i,t}$ is stationary.

$$\textit{Crisis}: \quad E(y_{1,crisis,t} y_{2,crisis,t}) = \lambda_1 \lambda_2 + \gamma_{2,1} \delta_1 \tag{4}$$

Comparing (3) and (4) shows that the change in the covariance between two states is $\gamma_{2,1}\delta_1$. Therefore, the significance of $\gamma_{2,1}$ can be examined by testing the statistical significance of this change.[4] This approach is adopted by Dungey et al. (2002; 2003). Their results show that there were substantial international contagion effects resulting from both the Russian and the LTCM crises.

b. Multiple equilibria model

Besides the unanticipated shock model, there is another stream of studies that consider the latent shocks under a multimodal framework. Changes in investors' expectations, beliefs and thus behaviours during the crisis period are common explanations for contagion in the analytical studies (Dornbusch et al. 2000). Such changes imply that the underlying distribution of asset returns should be mutimodal in general, i.e. the underlying model has two or more stable equilibria. In an N-equilibria case, these properties can be captured by a mixture of distributions:

$$f(y_{i,t}) = \sum_{j=1}^{N} \phi_j f_j(y_{i,t}) \tag{5}$$

where $f(y_{i,t})$ is the probability density of asset return $y_{i,t}$; ϕ_i are weights of individual densities $f_j(y_{i,t})$ in the mixture such that $\sum_{i=1}^{N} \phi_i = 1$.

It is however rather difficult to formulate a model of contagion related to these changes as they are generally not observable. Fratzscher (2000) and Jeanne and Masson (2000) adopt the multiple equilibria model into their empirical studies by employing the Hamilton Markovian switching model (Hamilton, 1990). They found that contagion effect is the most important factor of currency crises in 24 emerging economies during 1986 - 1998. See their papers for the specific formulations and Masson (1999) for a qualitative discussion of the approach.

ii. *Comovement analysis*

When an exogenous shock transmits from the first victim to the others, the financial markets of the subsequent victims are likely to respond in a similar way as the first one, causing comovements. Such comovements of financial market variables (e.g. asset return and volatility) are therefore important hints of contagion. In practice, analysing the correlation coefficient is the most straightforward way to investigate such comovements, while the principal component analysis is an alternative way to identify common factors in the movement of the financial market variables.

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[4] The parameter δ_1 is positive by assumption; therefore both positive and negative changes are valid as a proof of contagion as both signs represent evidence of contagion via the impact of unanticipated shock in the factor model.

a. Correlation test for contagion

Among all of the empirical methods adopted in the study of contagion, the correlation and covariance analysis is the most straightforward approach. These studies test for the significance of the increase in cross-market correlation during the pre-identified crisis period when compared to the tranquil period. For example, Baig and Goldfajn (1998) use the correlation analysis to test for contagion in the equity, currency and money markets in emerging economies during the Asian financial crisis in the late 1990's. They found that correlations in currency and sovereign spreads increased significantly during the crisis period, whereas equity market correlations offered mixed evidence. However, as there is a problem of heteroskedasticity in the estimation of the correlation coefficients, the estimated correlation coefficients during the crisis period are in general upwardly biased, and hence a test based on the biased correlation would imply spurious contagion. To tackle this problem, Forbes and Rigobon (2002) propose an adjustment for the correlation coefficient during the turmoil period. Consider a test for the existence of contagion between economy 1 and economy 2, in which economy 1 is the origin of the crisis. The standard deviations of asset market returns in economy 1 during the normal period and those during the turmoil period are $\sigma_{1,normal}$ and $\sigma_{1,turmoil}$ respectively. It is common to see $\sigma_{1,turmoil} > \sigma_{1,normal}$. If, in addition, there is no change to the fundamental relationship between the asset returns in the two markets, then the correlation of asset returns during the turmoil period will be larger than that during normal times, i.e. $\rho_{turmoil} > \rho_{normal}$. According to Forbes and Rigobon (2002), the adjusted correlation is given by:

$$\tilde{\rho}_{turmoil} = \frac{\rho_{turmoil}}{\sqrt{1+\left(\frac{\sigma^2_{1,turmoil}}{\sigma^2_{1,normal}}-1\right)\left(1-\rho^2_{turmail}\right)}} \tag{6}$$

This is a non-linear scaling function, which decreases with respect to the change in variance of equity return in economy 1.

To examine the existence of contagion between equity markets in 1 and 2, the null hypothesis is: $H_0 : \tilde{\rho}_{turmoil} = \rho_{normal}$. The simple t-test for comparing the size of two correlation coefficients is used in this study. The test statistic is given by

$$T = \frac{F(\tilde{\rho}_{turmoil}) - F(\rho_{normal})}{\sqrt{\frac{1}{N_{turmoil}-3}+\frac{1}{N_{normal}-3}}} \tag{7}$$

where $N_{turmoil}$ and N_{normal} are the numbers of observation of the specified periods respectively; and $F(.)$ is the operator of Fisher's transformation

$$F(x) = \frac{1}{2}\ln\left(\frac{1+x}{1-x}\right) \tag{8}$$

Using this adjustment method, Forbes and Rigobon (2002) show that there was little evidence of contagion during the 1987 US market crash, the 1994 Mexican devaluation, and the 1997 Asian financial crisis.

b. Dynamic conditional correlation analysis

The dynamic conditional correlation model (DCC) proposed by Engle (2002) is another commonly used method in the study of contagious risk. Unlike the Forbes and Rigobon (2002) approach, the problem of heteroskedasticity is directly tackled during the estimation of the DCC, as the DCC is estimated by the standardised residual of GARCH model. The DCC model also allows other explanatory variable to be included in the estimation to ensure that the correlation coefficient is well controlled for exogenous changes. These features contribute to the popularity of the DCC as a measure of contagious risk and market integration in the literature. For example, Yu et al. (2007a,b) use the DCC to measure the degree of integration in equity and bond markets in Asia. Chiang et al (2007) measure the degree of contagion in Asian financial markets between 1996 and 2003 by the DCC. The IMF also used DCC as an indicator of cross-market return correlation in its regular surveillance report (See IMF, 2008).

c. Principal components analysis

Principal components analysis is an alternative way to identify factors of comovements of financial variables across countries/markets. In general, the principal components explain the underlying set of financial variables. In an N-variable case, if the variables are perfectly collinear, then all the variance of this set of variables could be explained by one principal component. On the other hand, N principal components are needed to explain the variance of these N variables if the variables are totally orthogonal to each other. Kaminsky and Reinhart (2001) study the comovement of four asset classes among 35 emerging economies from 1997 to 1999, with the equity market being found to have the largest comovement in these economies.

iii. *Model of non-linearities*

The linearity assumption on the relationship between asset returns and foreign shock is sometimes considered to be too strong in examining the extreme episodes. To this end, there are a number of studies which adopt non-linearity in their models. Favero and Giavazzi (2002) use a vector autoregressive (VAR) model to control for the interdependence among asset returns within the system, and then use the heteroskedasticity and non-normalities of the residuals from that VAR to identify unexpected shocks that may be transmitted across countries, which are being considered as evidence of contagion. Their results show that there were non-linearities in the propagation of devaluation expectation (i.e. contagion) among the members of the Exchange Rate Mechanism in the European Monetary System in the past few decades. In practice, their analysis starts with the following N-variate first-order VAR model:

$$z_t = \Phi z_{t-1} + v_t \tag{9}$$

where z_t are the pooled asset returns across the two states (normal and crisis) in the sample, Φ contains the coefficients and v_t is the reduced-form disturbance with zero mean and constant covariance matrix with the variance given by $E(v_i^2) = \sigma_i^2$, i = 1,...,N. The dummy variables which capture the outliers are defined as:

$$d_{i,k,t} = \begin{cases} 1 : | v_{i,t} | > 3\sigma_i^2 \\ 0 : \text{otherwise} \end{cases} \tag{10}$$

where the dummy variable is assigned the value of one for each observation that is an outlier. These dummy variables are then included in a structural model of asset returns. To illustrate, let's consider a model with two asset return series, and only one outlier is identified in each series, then the structural model is given as follows:

$$\begin{aligned} z_{1,t} &= a_{1,2} z_{2,t} + \theta_1 z_{1,t-1} + \gamma_{1,1} d_{1,1,t} + \gamma_{1,2} d_{2,1,t} + \eta_{1,t} \\ z_{2,t} &= a_{2,1} z_{1,t} + \theta_2 z_{2,t-1} + \gamma_{2,1} d_{1,1,t} + \gamma_{2,2} d_{2,1,t} + \eta_{2,t} \end{aligned} \tag{11}$$

Hence, both the joint test for the existence of contagion between the economies (i.e. $H_0: \gamma_{1,2} = \gamma_{2,1} = 0$) and individual test of contagion from either country to another (i.e. $H_0: \gamma_{i,j} = 0$, for i ≠ j) can be performed by estimating model (11).

Another remarkable example of non-linear model is that adopted in the currency market analysis in Eichengreen et al. (1995). In the study of currency crises in 20 industrialised economies, the authors found substantial contagion effects among these countries during the period of the 1950's to early 1990's. In a typical two-economy setup, their model can be written as follows:

$$Crisis_{2,t} = \gamma_{2,1} Crisis_{1,t} + \mathrm{B} X_t \tag{12}$$

where $Crisis_{i,t}$ are dummy variables equal to one when there is a crisis period in economy *i* and zero otherwise.[5] The variable X_t is a set of other possible explanatory variables and B is the corresponding coefficient matrix. Hence the test for the existence of contagion (from economy 1 to economy 2) in this model is again the significance of the parameter $\gamma_{2,1}$. Apart from this model, there are also some other studies of contagion that focus on the occurrence co-exceedance of asset returns by the multi-variate probability model (see Dungey et al (2004) for details).

[5] Crisis is defined as a period with large negative returns, which is in turn defined by a linear combination of the mean and the standard deviation of the Exchange Market Pressure Index (EMP). The EMP is constructed by the authors in the study to measure the pressure on an exchange rate based on the currency return.

2. Models with identified channels of transmission

The importance of transmission channels or fundamental linkages is usually being suppressed in the studies mentioned above, which focus on the investigation of the significance of the latent factor. On the other hand, there are some other studies which focus on the examination of the importance and/or relative importance of the identified transmission channels of shocks, such as bilateral trade, financial flows and economic similarities. Instead of focusing on the existence of contagion, most of these studies concentrate on the investigation of the importance of different transmission channels of contagion risks. To this end, the probability model is a common workhorse of this branch of studies, in which the importance of various channels is measured by their contributions to the probability of the occurrence of the crisis. The general model is as follows:

$$Crisis_{i,t} = \mathrm{A}(Channel_{0,i,t}) + \mathrm{B}X_t \qquad (13)$$

where $Crisis_{i,t}$ is a dummy variable equals to one during the crisis period in economy *i* and zero otherwise; X_t is a set of other possible explanatory variables and B is the corresponding coefficient matrix; $Channel_{0,i,t}$ is a variable (or a set of variables) which measures the intensity of the transmission channel in question between the identified "ground zero" economy and economy *I*, with its corresponding coefficient matrix being A.[6] The significance of the transmission channels is thus indicated by the significance of the coefficient A.

Glick and Rose (1999) use bilateral trade measures as the channel variable, providing evidence that the patterns of international trade are important in understanding how currency crises spread. By adopting the same approach, van Rijckeghem and Weder (2001) present evidence that bank lending, as opposed to trade linkages and country characteristics, can also help explain contagion. Caramazza et al. (2000) also show that the high level of vulnerability to common creditor is highly related to regional contagion.

V. CONCLUDING REMARKS

This note provides an overview of the conceptual framework as well as a number of important empirical tests for the presence and characteristics of contagion in financial markets in the existing literature. While the literature in this area is vast, there has yet been little consensus in the definitions, causes and measurement of contagion. Despite this, contagion is an important feature of financial crises which policy makers have long been trying to manage and prevent.

A review of the channels of contagion in this note provides some policy perspectives on crisis management and prevention. It is interesting to note that most of the contagion channels discussed above do not require irrationality for shock transmission. Nevertheless, due to market imperfections and the presence of multiple equilibria involving information asymmetries, the price movements that occur in one market or

[6] The "ground zero" economy is the source (or first victim) of the crisis during time *t*.

country as a result of contagion from elsewhere can sometimes be excessive relative to full-information fundamentals. This suggests that reducing information asymmetries by increasing the transparency of government policies and information, and increasing disclosure requirements on financial institutions may improve market functioning and reduce unnecessary contagion.

At the same time, the sources of contagion through self-fulfilling expectations and wake-up call suggest that it is important to reduce macroeconomic vulnerability. Indeed, crises may be difficult to predict in a world with multiple equilibria, making it less possible to have an accurate prediction on the timing of the crises. However, it may still be possible to gauge the relative vulnerability of countries to crises. Empirical evidence suggests that the degree of vulnerability depends on the relevant fundamentals being in certain ranges, so that some economies are more susceptible than others.

While most of the existing methodologies focus on identifying contagion, it may be more useful for policymakers to explore what causes a particular economy to be more vulnerable to contagion than others, and whether economies which have experienced a crisis will become more or less vulnerable to contagion in future financial crises. While the overview of the conceptual framework on the transmission mechanisms of shocks given in this note may offer a better understanding on the causes of contagion, further empirical research in this area will be valuable. To this end, crisis periods may be used as windows to help identify these transmission mechanisms, rather than being emphasised as periods that generate new types of transmission mechanisms.

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